MONTANA WATER CENTER

Annual Report
Fiscal Year 2004

September 2004

The Montana University System Water Center, located at MSU-Bozeman, was established by the Water Resources Research Act of 1964. This act created and funded Water Resources Research Institutes at land grant universities in 54 states and territories. The mission of the Montana Water Center is *to mobilize the resources of Montana's public universities to resolve the state's water problems*. It does this by sponsoring water-related research, providing training and education for current water professionals, and educating future water professionals.

The Huffman Building on the Montana State University campus.

MONTANA WATER CENTER

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The National Research Council, the Nation's pre-eminent scientific organization, has just completed an examination of the U.S. water research enterprise that was chartered by Congress. The Council prefaces its report to Congress thus:

> *At the dawn of the 21st century the United States faces a panoply of water problems that are significantly more numerous, complex and larger in scope than those of the past. Serious issues about how water resources are to be protected and managed are not confined to one or several regions; they are found nationwide. Increasingly, the science needed to resolve these water issues in workable ways is not available.* [1]

The report goes on to offer recommendations for how water research can best be organized to meet these complex modern problems.

The increase of water problems is not news to those who follow public affairs in Montana. The technical complexity of these issues, and the need for a sophisticated understanding of natural and human processes to resolve them, are also not foreign concepts in our state. Montanans are pragmatists, and they base their water-resource choices on a firm base of knowledge. Fishery managers collaborate with landowners to learn the needs of threatened fish species, and devise practical means to meet those needs. County commissioners seek information on the hydrologic connections between ground water and surface water, so that their permitting decisions are well-founded. Public water system customers participate in lengthy processes to identify and protect drinking-water sources. Landowners undertake the 'watershed management' process with their neighbors, becoming experts on water quality.

How does the Montana Water Center fit into these activities? In a fundamental way: the Center is officially charged to identify needs that can be served by water research and education, and to mobilize the resources of our state's university system to fill those needs. We work daily with scientists, water managers and decision-makers. Ultimately, though, anyone who uses or enjoys our state's water resources is our client. If we're doing our job right, all Montanans will benefit. This is a short summary of how we did our job during Fiscal Year 2004, July 2003 - June 2004.

[1] Confronting the Nation's Water Problems: The Role of Research. June, 2004. Water Science and Technology Board, National Research Council of the National Academies. Washington, D.C.

PROGRAM HIGHLIGHTS

Fisheries Health: This year we brought out the *Proceedings of the 7th International Symposium on Fish Physiology, Toxicology and Water Quality,* documenting a meeting the Center organized and conducted in Estonia in spring, 2003. Scientists and policymakers from 14 nations contributed to this publication, with topics ranging from the effects of pollutants on fish respiration, to the challenges facing trout as pristine areas undergo development. Montana State University has a distinguished history of leadership in the symposium series, and we were proud to continue this tradition with the 7th International Symposium.

With guidance from two national advisory boards, we are carefully re-directing the research program of the *Whirling Disease Initiative* away from basic biological investigations toward the testing of potential management approaches. This is a difficult change: the new research questions are multidisciplinary, large in scale and requiring several years to resolve. Many must draw on years of data and call upon public officials to approve environmental manipulations that may—or may not—benefit fisheries. This change follows from the Initiative's broad goal of delivering a set of tools to help fishery managers cope with whirling disease. This complex disease will never be fully eradicated from streams where it has taken hold, but the achievement of self-sustaining trout populations in these streams is the goal we strive for.

In only its second year, the *Wild Fish Habitat Initiative* has begun to yield concrete benefits for fishery managers. Montana's efforts to re-introduce native cutthroat trout to its former habitats have always been dogged by bacterial coldwater disease. One-half of all fry succumbed to this disease in a Montana hatchery before they could be placed in the wild. An Initiative project led by Dr. Al Zale and Dr. Eileen Ryce targeted the disease in the hatchery, identified its source and mode of spread, and recommended measures to curtail its toll on young cutthroats. These measures are being implemented successfully, so that the restoration of this native fish is now moving forward much more rapidly than just a year ago.

Drinking Water: For ten years, our *Drinking Water Technical Assistance Center* has focused on helping small public water systems provide safe water economically. Our work has concentrated in two areas: developing training materials for the professionals of the drinking-water industry, and sponsoring research and development of treatment and management techniques specific to small systems. This year a special grant from the U.S. Environmental Protection Agency allowed us to add a third element. With collaborators from the Montana State University Departments of Microbiology and Civil Engineering, the Water Center convened 55 experts from 15 developed nations in a formal colloquium setting. The purpose was to identify problems common to small systems everywhere, and propose approaches that could be translated from one nation to another to help small water utilities do their jobs. The colloquium was a resounding success, and now its findings and recommendations are beginning to feed into policymaking and practice at various levels in several nations.

Water Information and Services: This year the Water Center instituted a monthly E-newsletter, featuring a researcher biography, current funding opportunities and an events calendar. This is now distributed to

more than 900 people. Not all our clients are E-connected, but those who are tell us this newsletter is a very convenient and engaging way for them to stay up to date on the business of water in Montana. We also completed the Montana Watershed web site and watersheds projects database, assisting those searching for specific watershed information in Montana. These tools are complemented by in-person gatherings such as the annual Montana Water Conference which we host each fall for 150 water professionals.

MONTANA WATER CENTER BASICS

The Montana Water Center is funded principally by grants from federal, state and local public agencies. It also receives modest foundation funding, and collects fees for the use of the Wild Trout Research Laboratory. In Fiscal Year 2004 the Center's budget was $2.3 million. The Center did not receive financial support from the Montana Legislature or from Montana State University.

We have recently experienced a substantial enlargement in our project portfolio, and this year we responded with staffing and facility changes. The Center now has Assistant Directors for Training, Outreach and Research. Kevin Kundert, who has led the multimedia development team for years, is our Assistant Director for Training. Following eight years as a fish disease research administrator, science communications wizard Susan Higgins has taken on the role of Assistant Director for Outreach. We were fortunate to recruit Liz Galli-Noble as our Assistant Director for Research, following her work for over four years as Project Manager of the Governor's Upper Yellowstone Task Force. Barb Coffman has also joined the Water Center, working from offices at MSU-Northern in Havre. Barb is a Research Engineer who develops materials for our drinking-water and wastewater training products. Many of our collaborators know Barb from her previous positions with the Montana Environmental Training Center, the Montana Salinity Control Association, and most recently the Montana Section of the American Water Works Association.

This year the Water Center's multimedia development team occupied newly-remodeled quarters in what was a family-housing unit situated between our main office in the Huffman Building and the Wild Trout Research Lab. A second, adjoining unit has just been renovated, and the research team is taking up occupancy there. Given the acute shortage of office space at the university, we're pleased we've been able to take on these convenient and congenial facilities.

This year our projects supported 20 undergraduate and graduate students, and one student intern each at MSU-Billings and Carroll College. The Water Center served as the sponsoring organization for 36 research grants, of which 24 were conducted at Montana universities. Part of our job is to bring in water knowledge generated elsewhere to benefit the people and resources of Montana, but we also take great pride in generating new water knowledge here and sharing it outside the state. This global give-and-take is crucial if we are to effectively tackle the difficult water issues that confront Montana in the 21st century.

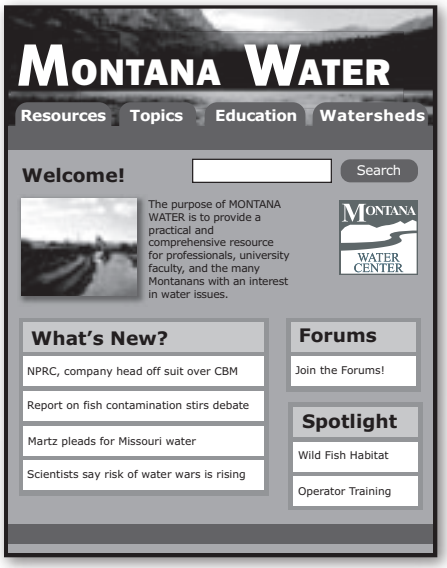
Gretchen Rupp, Director
August 2004

Gretchen Rupp, Kevin Kundert, Justin West, Nick Dunbar, Brooks Walch, Vince Cusomato, Ken Glynn, Sue Faber, Alicia Paz-Solis, MJ Nehasil, Rose Adams, Cal Fraser, Molly Boucher, Amy Rose, Liz Galli-Noble, Eve Davey, Sue Higgins

During Fiscal Year 2004, the Montana Water Center developed and sponsored several tools and forums for distributing water information.

ELECTRONIC OUTREACH

Montana Water Web site and E-News. "Montana Water" is an electronic hub on all things water in Montana. This web site of the Montana Water Center and partner agencies is maintained daily to bring the latest news items, water events, topic updates and community forums to water interests in the state and region. As part of its clearing house function for researchers, educators, agency personnel and watershed groups, we've added an electronic newsletter, issued monthly, containing the latest feature stories. You can view *Montana Water* and archives of the *Montana Water News* e-newsletter at http://water.montana.edu.



Ecosystem Restoration Web site. Few places remain where human activity has not altered the function of endemic ecosystems. A century ago little consideration was given to the return of disturbed land to a natural state, yet today environmental quality is a societal priority. This web site is committed to that priority and to the technical challenge of achieving ecological restoration. Its goal is to provide ecological restoration tools to designers, managers and practitioners in a web-based information repository. Contained within the site are case histories, images, educational guides, and links to literature and supporting web sites. The site can be accessed at http://ecorestoration.montana.edu.

TECHNICAL ASSISTANCE

Blue Water Task Force. Created in 2000, the Blue Water Task Force responded to an increasing need to collect water quality information for the Upper Gallatin River. As the managing partner in this project, the Montana Water Center trained citizens in water monitoring techniques, promoted community education and coordinated data collection in the watershed. This year, the Task Force entered a new phase in which it will operate independent of university support. We appreciate the fine efforts of Blue Water program manager, Michelle White, who guided this work before moving on to a new position in another state.

CONFERENCES

20th Annual Montana Water Conference. With the Montana Section of the American Water Resources Association, the Water Center each year organizes the Montana Water Conference. This year the conference was held in Butte, Montana with a focus on the post-mining restoration of the Clark Fork River Basin. It began with a pre-meeting field trip to the Montana Resources Inc. mine and the new Horseshoe Bend water treatment plant. Then our two-day format was stretched to the limit with a record number of technical presentations. A plenary session highlighting Superfund issues in the Butte area opened the conference followed by concurrent sessions dealing with ground water, surface water, watershed management, floodplain issues, and a new session devoted to Internet-based water information. Hydrologist Phil Farnes closed the conference with an update on climate change in Montana. Each year, we like to highlight student accomplishments, and several awards were issued to superior student presenters. A web-based archive of AWRA's Montana Section activities and meetings is found at http://www.awra.org/state/montana/.

A field trip to the Montana Resources Inc. mine.

70th Annual Water School. On the Montana State University (MSU) Bozeman campus, water and wastewater system operators from throughout the state annually receive four days of training and workshops for managing their local systems. At the close, operators may sit for the water/wastewater certification exam administered by the Montana Department of Environmental Quality. This program is also facilitated by the Montana Environmental Training Center, the Montana Water Center, and the MSU Civil Engineering Department. *Water School* for operators and managers marked its seventh decade in September 2003. More than 175 operators attended along with 16 vendor groups.

Water Systems Teleconferences. Twice a year, the Montana Water Center coordinates live American Water Works Association teleconferences to several Montana downlink sites. These 3.5-hour teleconferences provide exceptional value to individuals in the drinking water industry by allowing them to obtain state-of-the-art information on treatment technology, regulatory issues and best management practices. *Water Storage* and *Utility Case Studies: Facing Everyday Challenges* were this year's topics at eight downlink sites where over 130 water professionals attended.

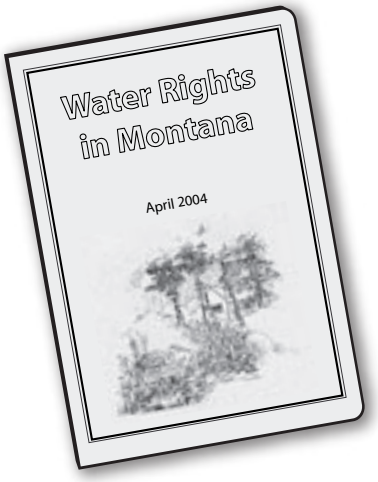
Montana Watershed Symposium. Center staff mambers served on the planning committee for the December 2003 Montana Watershed Symposium, the purpose of which was to create a dialogue among landowners, watershed managers, policymakers and scientists to identify research and management solutions to pressing watershed problems. *Opportunities for Communities and Landscapes Watershed Symposium,* chaired by the Montana Watershed Coordination Council, took place in Great Falls. This meeting brought new visions for the future management of Montana watersheds.

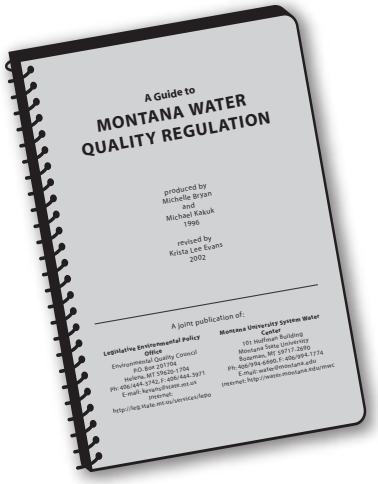
Whirling Disease Symposium. Continuing its longstanding collaboration with the Whirling Disease Foundation, the Montana Water Center co-sponsored the Tenth Annual Whirling Disease Symposium, *Whirling Disease Management: Practicalities and Realities*. Held in Salt Lake City in March 2004, this national meeting focused particular attention on building management solutions and a risk assessment model for evaluating the disease. The Water Center provided funding, planning assistance and moderators for the symposium.

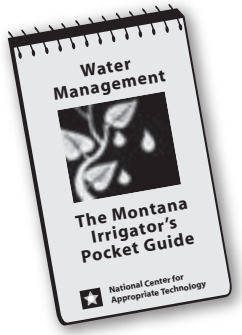
PUBLICATIONS

Often legislators, landowners and scientists seek thorough, up-to-date primers on contemporary water issues in Montana. The Montana Water Center enjoys a collaboration with the Environmental Quality Council, the Montana Department of Environmental Quality, the Montana Department of Natural Resources and Conservation, and other agencies to fund, produce, and distribute these guides statewide and regionally. This year, three publications were updated and republished:

- *Wading into Water Rights.* Revised for 2nd printing in 2004. A publication of the Legislative Environmental Policy Office and the Montana Water Center.
- *A Guide to Montana Water Quality Regulation.* Revised for 2nd printing in 2004. A publication of the Legislative Environmental Policy Office and the Montana Water Center.
- *Water Management: The Montana Irrigator's Pocket Guide.* Revised and reprinted in 2003 by the National Center for Appropriate Technology.







The Water Center also maintains a lending library of paper documents relevant to Montana water issues. These are catalogued on the web site and circulated at no cost to those who request them. After reorganizing and publicizing the library, we saw a great increase in its use this year.

POLICY REVIEW

To keep abreast of emerging policy issues in Montana that could benefit from Water Center involvement, staff members participate in statewide meetings and conferences of the Montana Legislative Environmental Quality Council, the Montana Watershed Coordination Council, the Water Activities Work Group, and various *ad hoc* committees. As appropriate, we collaborate with other water centers to develop and forward policy recommendations at the national level. At the end of the fiscal year, the NRC Water Science and Technology Board brought forth its study, *Confronting the Nation's Water Problems: the Role of Research*, and we began to take part in deliberations on prioritizing and funding water research at the national level.

The U.S. Geological Survey's 104(b) program addresses a spectrum of state water problems, and we are privileged in Montana to put these funds to use on pressing water issues. The program is guided by our Water Resources Research Advisory Committee. Montana investigators and graduate students study topics such as coalbed methane development, surface-water/ground-water interactions in areas of agricultural development, and the intricacies of urban water quality degradation. The Advisory Committee identifies research priorities, oversees peer review of proposals, and recommends projects for funding. You can find full 104(b) project reports at: http://water.montana.edu/topics/research/projects/.

PROJECTS ONGOING OR COMPLETED IN FY 2004

Quantitative assessment of the effectiveness of post-fire erosion control techniques. **Scott Woods and Thomas DeLuca, University of Montana.** This study evaluates the effectiveness of three commonly-used hillslope erosion control treatments: straw wattles, mulching and aerial seeding, for reducing post-fire erosion rates. Two areas of Montana affected by forest fires in 2001 and 2002 serve as study sites. One experiment is assessing the effectiveness of straw wattle installation and mulching in reducing post-fire erosion rates from hillslope plots exposed to natural rainfall. A second experiment assesses the effectiveness of aerial seeding and mulching in reducing post-fire erosion from small plots exposed to simulated rainfall. Another study is looking at effectiveness of aerial seeding in reducing erosion rates from hillslope plots exposed to natural rainfall. These data will help land managers select more efficient erosion control treatments, thus helping to reduce the costs associated with mitigating forest fire effects. This project was extended into the 2004 - 2005 research cycle.

Pharmaceuticals in septic system effluent. **William Woessner and Emily Godfrey, University of Montana.** Concern has been raised as to the fate of pharmaceuticals and personal care products found in sewage, yet their fate in household or community septic systems is poorly known. Approximately 25-35 percent of homes in Missoula, Montana rely on septic tanks for waste disposal. This study attempted to characterize the occurrence and concentrations of pharmaceuticals in septic system effluent, and examine the potential for the contamination of shallow aquifers. Sewage entering a wastewater treatment plant was also sampled. The occurrence of 19 drug residues and three drug metabolites of both prescription and non-prescription drugs in wastewater, ground water and surface water were analyzed.

In raw wastewater samples, 18 of the 22 pharmaceutical compounds were present in septic tanks, 12 were detected in treatment plant influent, and nine were detected in treatment plant effluent. The most frequently detected non-prescription drugs in the raw sewage samples were acetaminophen, caffeine, nicotine and a caffeine metabolite (paraxanthine), and a nicotine metabolite

(cotinine). Prescription drugs examined in the raw sewage were detected in about 30 of the samples with the exception of warfarin which was detected in approximately 77 percent of the samples. Other frequently-detected prescription drugs were codeine, trimethoprim and carbamazepine. Ground water receiving septic effluent from a high school drain field contained measurable quantities of caffeine, carbamazepine and sulfamethoxazole. Samples of shallow ground water within the unconfined aquifer underlying the city of Missoula and the adjacent county exhibited detectable concentrations of caffeine, carbamazepine, cotinine and trimethoprim.

Topography, ground-water dynamics, and soil frost: first-order controls on snowmelt runoff dynamics and plant species distributions across an upland-wetland transition. **Brian McGlynn, Montana State University.** This project is studying the controls on snowmelt flow pathways, frost depth, and plant species distributions across an upland–wetland transition. It is a first step in the development of a conceptual model of snowmelt flowpaths and hydro-ecologic dynamics at the landscape scale. The hydrologic dynamics and plant species distributions appear tightly linked at Red Rock Lakes in the Centennial Valley, making this an ideal site for new investigation in the emerging field of hydroecology.

Collecting data in the Centennial Valley.

Understanding and predicting changes in the microbial ecology of mine tailings in response to the addition of dissolved organic carbon. **Paul Sturman, Montana State University.** The purpose of this research is to predict the response of iron-oxidizing and sulfate-reducing microbial populations to various organic carbon addition strategies. Results will help field engineers select the most appropriate sources of organic carbon for field application to mine tailings as well as provide tools for assessing the microbial condition of mine wastes prior to implementing a solution, and after a treatment is applied. Although remedial measures that rely on microbially-catalyzed reactions are in common use, we currently lack the tools to predict and measure responses of important microbial populations.

Potamopyrgus antipodarum *and baetid mayflies: temporal variation and community-level consequences.* **Billie Kerans, Montana State University.** This study investigated the consequences of the New Zealand mud snail *(Potamopyrgus antipodarum)* introduction on other macroinvertebrate populations. The mud snail's increasing densities, plus its feeding ecology and reproductive biology suggest that it could compete with other grazing macroinvertebrates, affecting the availability of food for Montana fish. Although this study did not demonstrate a clear effect of mud snails on baetid mayflies, it does suggest that the effect may change on a temporal scale, having a greater effect during times of lower productivity or during different developmental ages of baetid larvae. This study also showed that mud snails can depress periphyton food resources, but whether to a level that limits other species will depend upon biological attributes and competitive abilities of each species. Because mud snails appear to be strong competitors, they are likely to affect other macroinvertebrates that rely on periphyton as a food source. Finally, this study does not demonstrate a strong effect of mud snails on the growth of either brown trout or sculpins, but it does suggest that insectivorous fishes may adjust their diet according to changes in macroinvertebrate abundances caused by *Potamopyrgus*.

Recharge assessment of the Anaconda Mine near Belt, Montana. **Jon Reiten, Montana Bureau of Mines and Geology.** Decades of underground coal mining have resulted in acid mine drainage which has contaminated ground-water and surface-water resources in Belt, Montana. The acid mine drainage is lowering the pH of Belt Creek and increasing trace metals concentration in the stream. The goal of this project is to define the hydrogeologic regime in the vicinity of Belt so that recharge associated with old mine workings and the source of acid mine drainage can be delineated with certainty.

PROJECTS INITIATED IN FY 2004

Amphibian habitat distribution and population structure of Columbian spotted frogs **(Rana luteiventris)** ***in western Montana watersheds.*** **Lisa Eby, University of Montana.** In Montana, 60 percent of threatened and endangered species rely on wetlands to meet all or part of their seasonal needs. One-third of all amphibian species in Montana are listed as species of special concern and need lentic habitat (ponds or wetlands) for breeding. Conservation of these species requires a better understanding of how impacts to critical habitat affect population functioning at the watershed and landscape scales.

Dipnetting in Western Montana amphibian habitat.

This research examines the role lentic sites play in creating habitat needed for amphibian breeding and over-wintering in western Montana. It also studies the genetic population structure of *Rana luteiventris* (Columbia spotted frog). Investigators are assessing amphibian habitat by examining the distribution of potential breeding and over-wintering sites and the occurrence of beaver activity. Then, using focal watersheds, they are using aerial photos to assess rates of change of this critical habitat over the last 70 years in watersheds with and without beaver. They will determine if these amphibian populations are functioning as panmictic populations, metapopulations, or isolated populations, and whether the landscape changes associated with beaver activity (through altering the distance between breeding populations) may affect the genetic structure of amphibian populations.

Investigation of microbial ecology, structure and function in coalbed aquifers: Powder River Basin, Montana. **John Wheaton, Montana Bureau of Mines and Geology.** Coalbed aquifers supply water to vast regions in southeastern Montana. Currently, these aquifers are impacted by conventional coalbed methane (CBM) development and, as concerns of global warming increase, speculation that these aquifers may serve as repositories for industrial CO_2 suggests that additional future impacts are likely. The origin of CBM in the Powder River Basin is the result of microbial processes (biogenic methanogenesis). The success of CO_2 sequestration strategies will likely be a function of microbial activities as well. The project will identify the structure, diversity and presumptive function of the total microbial community within a specific methane-bearing coalbed aquifer in the Powder River Basin. It will conduct culture-based investigations that will help delineate the kinetic rates and pathways for methanogenesis. The goal is to generate data that will support more advanced studies of *in situ* gasification of coal as it relates to methanogenesis, CO_2 sequestration, and the development of technologies appropriate for sustainable methane development. Investigators foresee the value of these data as a means of moving toward a philoso-

phy of harvesting CBM rather than simply mining this resource at the expense of ground-water resources.

Evaluation of various methods to assess condition of perennial stream ecosystems. **Clayton Marlow, Montana State University.** Riparian and upland management policy throughout Montana and the Northern Rocky Mountain region is driven by the assumption that high ecological condition in riparian areas is indicative of good trout habitat and unimpaired water quality. Therefore, many on-the-ground management actions are based on improving trout habitat by improving riparian vegetation condition.

Unfortunately, there is little or no information that demonstrates linkages between riparian vegetation conditions and trout/aquatic macroinvertebrate populations. This work will provide insight into which visual (indirect) riparian assessment procedures give a fair measure of in-stream conditions, and will enable land managers to select assessment procedures that reflect the linkage between riparian vegetation, streambank stability, and in-stream habitat condition.

Assessing stream conditions.

Defining river recharge and three-dimensional areas of contribution to production wells adjacent to a losing river. **William Woessner, University of Montana.** The contribution of large gravel-bedded river systems to the ground-water supplies of alluvial valleys in western Montana is poorly understood. Rivers often act as sources of recharge when perched above the unconfined valley fill aquifer or they are directly connected to the water-table/ground-water system. Under these conditions, pumping may induce flow from the river to the adjacent production wells. In the Missoula valley, the Clark Fork River is perched above the Sole Source Missoula Aquifer which is unconfined and coarse-grained. Five large production wells adjacent the river in the eastern portion of the valley supply residents living on the valley floor.

Though high-yield production wells produce high-quality water, the area contributing water to these wells is poorly understood. It is suggested that over 50 percent of the ground water in the Missoula Aquifer is recharged by the Clark Fork River. However, the role of underflow from Hellgate Canyon and the underlying Tertiary sediments in contributing water to wells is unclear. Of further concern is the possibility that river water quality may be degraded from restoration actions at Milltown and in the upper Clark Fork River, a failure of the Warm Springs treatment system, and/or an accident associated with the rail and highway corridor. The impact of potential surface-water degradation on the produced ground water is a concern for the over 57,000 residences of the Missoula valley.

This work will establish data needed to assess conditions found in the Missoula valley, in similar settings in western Montana, and the region. The use of intensive sampling using ^{18}O and the collection of temperature data in the river, river bed, and adjacent ground-water system will produce a more detailed understanding of river/ground-water interconnections. Modeling will examine how changes in surface-water quality will impact aquifer water quality. The methods developed as part of this project will be transferable to numerous projects examining the connection between surface-water and ground-water systems and will allow managers to evaluate how changes in river chemistry will impact produced ground-water quality.

STUDENT RESEARCH FELLOWSHIP

This year the Montana Water Center and its Water Research Advisory Team initiated the Student Research Fellowship Program, an opportunity for undergraduate or graduate students at Montana institutions who are engaged in water research to apply for a $5,000 fellowship. We received 14 applications for the first fellowship. Megan McBride, studying with Norma Nickerson at the Institute of Tourism and Recreation Research at the University of Montana, was selected to receive the fellowship. Her study, *Recreation on the Upper Yellowstone River: Use and Place Attachment*, responds to a specific recommendation made in the final 2003 report of the Montana Governor's Task Force on the Upper Yellowstone River: "To study current conflicts and potential future conflicts arising from changing uses of the upper Yellowstone River."

Megan McBride, 2004 Student Research Fellow

Through on-site surveys, McBride's work will focus on recreationists' perceptions of the Yellowstone River to help identify current struggles and future conflicts that may emerge. Results will identify users' satisfaction with their recreation experience and the types of social conflicts present. McBride will focus on river reaches that receive heavy impacts from recreationists and other users—areas where conflicts may occur in the future.

INTERN PROGRAM

A training ground for incoming professionals keeps water science vital. In keeping with one of the most important elements of the Montana Water Center mission, we provide opportunities for undergraduate interns to mentor with the U.S. Geological Survey in field training positions. This year, intern Seth Davidson worked with USGS hydrologists in Helena, and Aroscott Whiteman worked out of Billings.

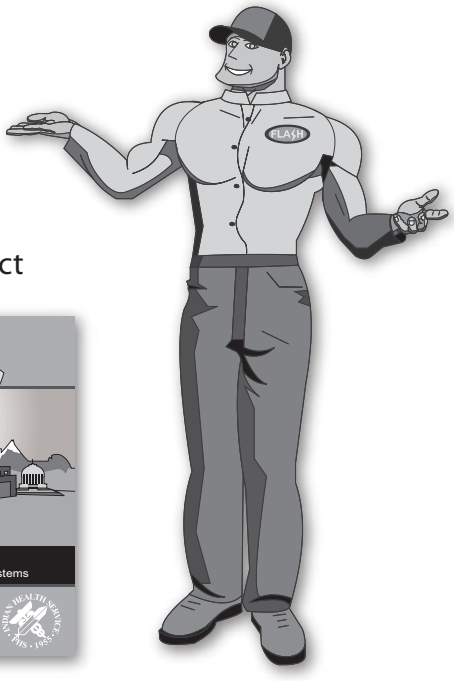
The Montana Water Center operates the flagship institution of an eight-center network of Small System Technology Assistance Centers. Funded by the U.S. Environmental Protection Agency (EPA), the centers work to protect public health, improve water system sustainability, and enhance regulatory compliance by small water systems. The centers apply university resources to address the needs of rural and small public water systems or public water systems that serve Indian tribes, in the areas of technology verification, testing of innovative technologies, and training and technical assistance.

Training tools developed by our Center may be used, downloaded or ordered (most are free of charge) from our training site: http://water.montana.edu/training/. Project descriptions and resources from all eight Technical Assistance Centers can be accessed on the TACnet web site maintained by the Montana Water Center: http://www.tacnet.info.

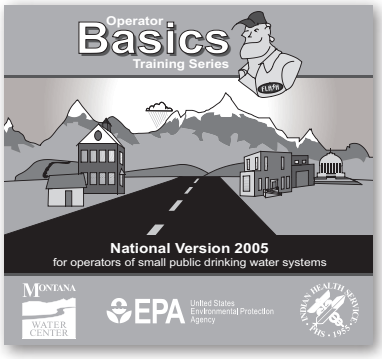
RESEARCH AND ASSESSMENT

***Toolbox to assess system microbial risk*. Phillip Butterfield, University of Washington, and Anne Camper, Center for Biofilm Engineering, Montana State University.** A multimedia training tool is in production now that will help operators and managers assess the vulnerability of their small systems to microbial contamination. A tutorial simplifies the use of this interactive spreadsheet application, leading personnel through a series of questions based on their water sources and treatment/distribution trains. When questioning is completed, the program ranks system components and their relative vulnerabilities, with interpretation and suggestions for abating the vulnerability. The user can then test the results of chosen actions before expending the capital to make changes in the real system. This tool will be available in late 2004 on the Water Center's training web site.

TRAINING TOOLS



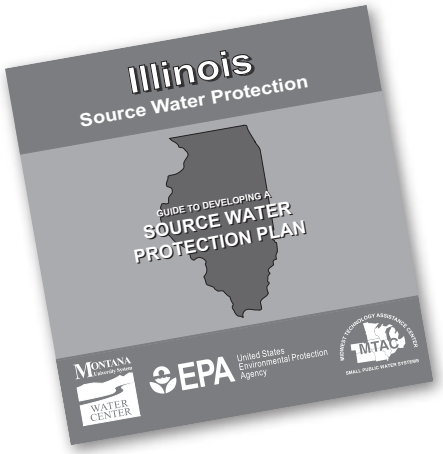
Operator Basics Training Series. The Center provides interactive training tools for small public water system operators and technical assistance providers throughout the United States. The core project is the Operator Basics Training Series. This year, our programming team has been developing a Wastewater Lagoon Module with funding from the Indian Health Service. Work also

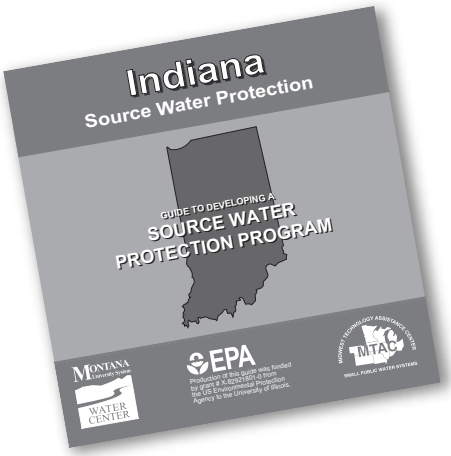


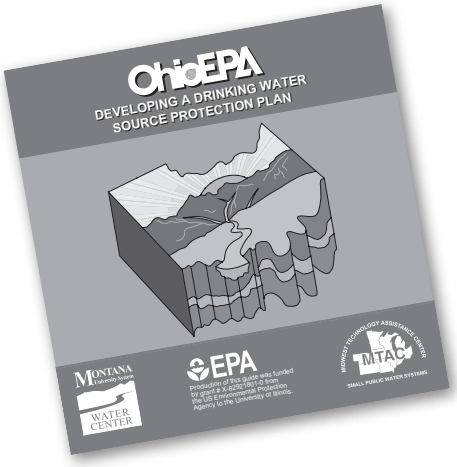
continued on the Small Surface Water Systems Module and an update of the Small Ground Water Systems Module. "Virtual Explorations" are also in production to challenge operators of each system type. The final product will be released early in 2005.

This training series can be obtained free of charge from the National Drinking Water Clearinghouse (800-624-8301), and will be available in multiple formats to fit the needs of our varied audience. Find more at: http://water.montana.edu/training/.

EPA Region V Source-Water Protection Training Guides. The Center was funded to produce Source-Water Protection training modules for states in the Great Lakes region. Based on our past experience with these tools, we've refined the product and have added several state-specific resources in collaboration with experts in Illinois, Indiana and Ohio. These tools are available online at http://water.montana.edu/training/.







Sanitary Survey Fundamentals. Development of this interactive CD-ROM tutorial was funded by the EPA. This "prep course" provides basic instruction on operation of public water systems, a specialized vocabulary, and better understanding of the in-depth Sanitary Survey workshops given by EPA's Drinking Water Academy and other organizations. We've incorporated 3-D fly-ins, animation, interactivity, games, narration, and video in this tool, all without the need for users to install a plug-in. The course takes about two hours to complete. Free copies can be ordered by calling the Drinking Water Clearinghouse at 800-624-8301. Refer to the Sanitary Survey Fundamentals Prep Course, product #DWCDTR19. The 153 MB program can be downloaded at: http://water.montana.edu/training/ssf/.

DRINKING WATER COLLOQUIUM

In May 2004 the Montana Water Center convened a three-day meeting at Montana State University. Fifty-five drinking-water scientists, engineers, system managers, regulatory authorities, and graduate students from fifteen nations were invited to participate. In a formal colloquium process, these experts systematically explored 1) health threats in small water systems; and 2) how different developed nations approach the provision of safe water by small systems, and the successes and shortcomings they have experienced. The ultimate goal was to help inform decision-making and policy formulation in the United States and other developed nations.

A summary presentation of findings and recommendations can be downloaded at http://water.montana.edu/colloquium/products/. The project final report is in preparation; it will be distributed broadly within the drinking-water communities of the participating nations. The colloquium was underwritten by a grant from the U.S. Environmental Protection Agency to the Montana Water Center.

Colloquium participants

Protecting
Public Health
in Small Water Systems

An International Colloquium

A colloquium working group takes a break.

WHIRLING DISEASE INITIATIVE

The Whirling Disease Initiative was established by Act of Congress in 1997. Its purpose is to conduct research that develops practical management solutions to maintain viable, self-sustaining wild trout fisheries in the presence of the whirling disease parasite.

The microscopic parasite *Myxobolus cerebralis*, which causes whirling disease in salmonid fish, has spread and infects hundreds of river and stream reaches throughout the United States. It was once believed to be relatively harmless to wild fish, but research in the mid-1990s found that it was decimating rainbow trout populations in some of the Rocky Mountain region's finest river fisheries. Most salmonids have been found to be susceptible. Whirling disease is therefore a major threat both to biological diversity and to the nation's multi-million-dollar fishing and tourism economy. The whirling disease parasite has been reported in 23 states, and has generated great concern among anglers, scientists, and fisheries managers. It is still spreading and affecting new fisheries. This parasite infects two very different hosts alternately: fish and aquatic worms (*Tubifex tubifex*). Therefore, reaching an understanding of its biology and ecology has required a long-term, large-scale research initiative.

General oversight of the Whirling Disease Initiative is provided by the National Partnership for the Management of Wild and Native Coldwater Fisheries. The National Partnership is a consortium of federal and state agencies, professional associations and private advocacy organizations that are concerned with the well-being of coldwater fisheries. In-depth scientific direction is given to the Initiative by its Steering Committee. The committee is made up of representatives from state fish and wildlife agencies, federal natural resource agencies, and the Whirling Disease Foundation. Working in collaboration with Montana Water Center staff, the Steering Committee prepares an annual research plan, issues requests for proposals, selects and approves projects for funding following scientific peer review, and distributes the research results within the scientific and fishery management communities and to other stakeholders. The Montana Water Center is the administrative entity that manages the program and coordinates outreach and educational activities.

Under the sponsorship of the Initiative, more than 100 research projects have been carried out by universities, public-agency scientists and private firms since 1997. A total of more than $8 million of federal and matching funds has been expended or committed for these projects. Students are involved in most projects, either as technicians or graduate research assistants.

2003-2004 Research Cycle

The following research projects, totaling $558,000 in grants and $516,270 in matching funds, have a project period May 1, 2003 to December 31, 2004.

***Evaluation of quantitative real-time PCR for rapid assessments of the exposure of sentinel fish to* Myxobolus cerebralis. Mark A. Adkison and Ronald P. Hedrick, University of California, Davis.** Researchers are testing the sensitivity and specificity of two new rapid and sensitive PCR assays that have already been developed at UC-Davis, and are comparing these to currently-used detection assays (PCR, histology, and pepsin-trypsin digest). To date, fish exposures and sample collection have been completed. Histology scoring is complete and TaqMan PCR samples have also been run. Single round and nested PCRs, PTD digests, and data analysis will now be their focus. If these methods test out, time can be saved in evaluating sentinel fish (fish exposed in the field) in future studies, and the progress of parasite infection in rainbow trout can be evaluated more effectively.

Determining the presence of whirling disease in the Columbia River Basin.

***Evaluation of management actions to control the spread of* Myxobolus cerebralis *in a lower Columbia River tributary.* Jerri Bartholomew and Antonio Amandi, Oregon State University, Corvallis.** This project is evaluating the dewatering of a private hatchery as a point source of whirling-disease infection in a tributary in the lower Columbia River basin, and assessing the likelihood of whirling disease reintroduction by infected anadromous salmon. Four sentinel exposures trials have been conducted at 10 locations to determine the presence or absence of whirling disease. To date, the data indicate that at the time of hatchery closure the parasite was detected in high prevalence in the hatchery and at a low prevalence in the mainstem of the river. Infection also occurred in fish exposed several miles downstream. Worms were also sampled at each site in order to assess the relative abundance of *T. tubifex* and for genetic analysis. Samples from the hatchery contained the highest abundance of worms and *T. tubifex*. Genetic analysis of tubificids collected at Clear Creek identified three different *T. tubifex* lineages from Oregon. Fifty adult spring Chinook salmon that spawned in the Clackamas drainage have been collected thus far.

***Testing impacts of channel modifications to reduce* Tubifex tubifex *habitat.* Eric Bergersen, Colorado Cooperative Fish and Wildlife Unit; Terry Waddle and Jim Terrell, U.S. Geological Survey; and Kevin Thompson, Colorado Division of Wildlife.** This study is using information from a channel bed survey and hydraulic simulation model completed in Willow Creek, Colorado to predict changes in *T. tubifex* habitat at a Poudre River, Colorado site. The outcome will be a set of flow scenarios and channel configurations that create the least amiable habitat for tubifex survival. Tubifex worms have been collected from both streams and examined for genotype. Benthic samples are being characterized to determine the nature of any relationship between worm biomass and sediment composition. Stream cross-sections were surveyed and mapped to find areas of sediment accumulation. The channel modifications—filling of a backwater area, conversion to an emergent-plant wetland and stabilization of eroding banks—has been completed.

Effect of riparian zone and associated stream substrata on* Tubifex tubifex *density and infec-

***tion rate with* Myxobolus cerebralis. Deborah Cartwright, Vicki Blazer, and W. Bane Schill, U.S. Geological Survey, National Fish Health Laboratory.** The objectives of this project are to determine if leaf litter and, hence, riparian zone characteristics, will affect *T. tubifex* density and/or the ability of resident worms to become infected with *M. cerebralis* spores and release infective spores. *T. tubifex* have been collected from eleven sites in New York and Pennsylvania supporting populations of brown trout, rainbow trout or both; some sites were infected with whirling disease and some were not. Worms will be examined for genotype and parasite load. Laboratory exposure of worms to various types and concentrations of leaf litter have begun. These worms will be infected with whirling disease to trace the effect of leaf litter on disease susceptibility.

***Epidemiology of whirling disease: an integrated study of the Rock Creek drainage, Montana.* Willard O. Granath and Michael Gilbert, University of Montana; Billie Kerans, Montana State University; and Eric Reiland, Montana Department of Fish Wildlife and Parks.** This study is a continuation of a five-year study to determine the epidemiology of whirling disease throughout a natural system—the Rock Creek drainage of Montana—including the relationship of infected worms to whirling disease infection rates and severity in trout. Worm infection rates of 0 to 3 percent were observed during recent field seasons. No obvious correlation between parasite release from the worm and temperature/photoperiod has been observed in the field. Correlation between streamflow and infection severity is being examined with data from several years, most recently June 2003. Sentinel fish were deployed in several places to locate an apparent point source of whirling disease infection in the drainage.

Pelican Creek in Yellowstone National Park.

***Development and testing of risk assessment tools for* Myxobolus cerebralis *infection of native cutthroat trout in Yellowstone National Park.* Billie Kerans, Montana State University and Todd Koel, National Park Service.** Investigators are examining the spatial and temporal variation in whirling disease risk to cutthroat trout populations, the biological and physiochemical factors that correlate with infection risk, and the life histories of Yellowstone cutthroat trout that possibly could allow some subpopulations to have low risk of infection. They collected physical and water-quality stream data during summer 2003. They also monitored disease risk using *in situ* enclosures of sentinel Yellowstone cutthroat trout in three reaches of the Yellowstone River, Pelican Creek, and Clear Creek during three time periods in July, August, and September 2003. Most fish have been removed and are now being prepared for disease diagnosis. They have also collected wild-reared, age-zero Yellowstone cutthroat trout in these three streams to estimate infection prevalence in young, wild fish. They had planned to collect oligochaetes for assessment of tubificid assemblages and prevalence of infection, but found existing methods for identifying diseased worms not sufficiently sensitive, and so are developing new methods. Overall, the data will be used to develop a risk-assessment model for whirling disease transmission in Yellowstone National Park.

***Analysis of non-lethal techniques for detection of* Myxobolus cerebralis *in naturally exposed rainbow trout.* Molly Toner and Linda Stanton,**

U.S. Fish and Wildlife Service. The goal of this project is to provide non-lethal, highly-sensitive DNA techniques for field application. It uses a genetically-based DNA diagnostic approach to detect the whirling disease parasite in fish exposed to various doses of the parasite in laboratory and field environments. Samples were taken from rainbow trout fins or skin scrapings. Fish were exposed and samples tested for presence of *M. cerebralis* at 24 hours or, 1, 2, 3, 4, 5, 7, 9, and 11 months post exposure, using nested PCR. To date, the nested PCR has been completed on 230 field samples and 200 lab samples. Preliminary study results are promising, showing high positive percentages for presence of *M. cerebralis* in field and laboratory 24-hour post-exposure samples. Completion of sample analysis is needed before further conclusions can be made.

Development of molecular markers linked to whirling disease resistance in rainbow trout. **Eric Wagner and Chris Wilson, Utah Division of Wildlife Resources; and Karen Mock and Mark Miller, Utah State University.** The objective of this project is to develop molecular markers associated with whirling disease resistance in rainbow trout in an effort to develop rainbow trout brood stocks resistant to *Myxobolus cerebralis*. Preliminary research conducted by Montana Fish, Wildlife and Parks in 2002 indicated that the Fish Lake-DeSmet strain had significantly less pathology than other rainbow trout strains. Unfortunately, in this follow up study the Fish Lake-DeSmet group displayed much higher histology scores than the previous group and had high levels of deformities, similar to other susceptible rainbow trout. Further work has involved developing standard protocols for analysis of the major histocompatibility complex that may play a role in disease resistance in trout. Also, four promising strains of rainbow trout from Utah and three locations in Montana have been exposed to the disease, and are being tested histologically. Preliminary data for two of the strains suggest that one is highly susceptible to the disease and the other is resistant.

2004-2005 Research Cycle

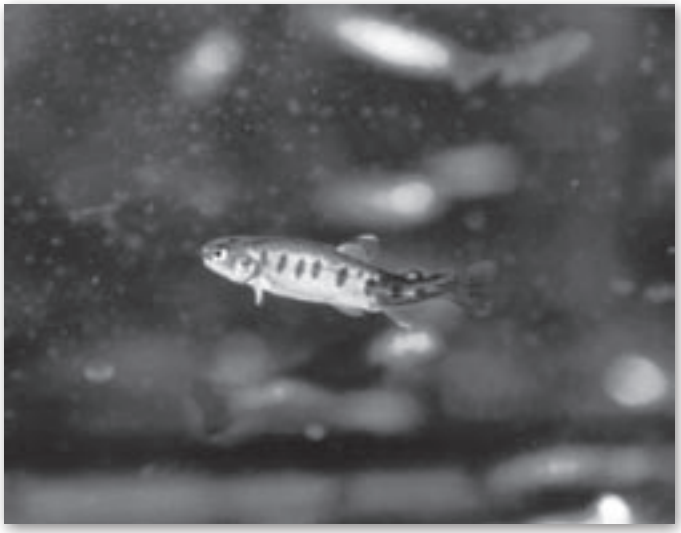
The following research projects, drawing on $662,000 in grants and $343,870 in matching funds, began May 1, 2004 and will conclude December 31, 2005.

Non-lethal testing for **Myxobolus cerebralis** ***infection by Enzyme Linked Immunosorbent Assay (ELISA).*** **Mark A. Adkison, Ronald P. Hedrick, and Garry O. Kelley, University of California–Davis.** The goal of this project is to determine the sensitivity and specificity of a non-lethal immune-based enzyme linked immunosorbent assay (ELISA) for the detection of *Myxobolus cerebralis* infections in fish. Currently used methods require killing the fish in question. The ELISA assay looks for and measures antibody against *M. cerebralis* circulating in the serum of trout, which can be collected without harming the fish. More specifically, the project goal is to determine how early researchers can consistently identify infected fish by measuring anti-*M. cerebralis* antibodies in their serum. Confident in the sensitivity of the ELISA assay itself, researchers are attempting to determine when fish produce enough *M. cerebralis* antigen-specific antibodies to detect. They also seek to confirm the belief that TAM lysate antigens are sufficient to measure antibodies produced at all stages of the infection.

Assessment of the risk of **Myxobolus cerebralis** ***introduction as a result of straying adult steelhead and spring Chinook salmon in the Columbia River Basin.*** **Jerri L. Bartholomew and Antonio Amandi, Oregon State University; and Susan K. Gutenberger, U.S. Fish and Wildlife Service.** One of the critical unknowns for managing systems containing anadromous fish is whether straying of infected adult fish plays a significant role in introducing *Myxobolus cerebralis* and other pathogens to new areas. Data from the Deschutes River risk assessment suggests that this is true. However, it is likely that stray rates differ among rivers. Analysis of data for recovery locations of adult salmon could identify rivers at high risk for introduction. This project assesses the role of straying adult steelhead and spring Chinook

salmon in disseminating *M. cerebralis* in the Columbia River Basin (CRB). The study integrates and expands on previous work on the effects of *M. cerebralis* on anadromous salmonids in the upper CRB, risk management assessments conducted on the Deschutes River (central CRB), and current investigations on establishment of the parasite in a tributary of the lower CRB. This work will: (1) estimate the frequency of adult salmonids straying into tributaries; (2) determine the proportion of these fish infected with *M. cerebralis*; (3) integrate these data with data from the Deschutes River to develop estimates of introduction risk for focal tributaries; and (4) determine infection efficiency under differing *T. tubifex* densities, susceptibilities, and under different flow regimes using a laboratory model.

***Susceptibility of Rio Grande cutthroat trout* (Oncorhynchus clarki virginalis) *to experimentally induced infection with* Myxobolus cerebralis. Colleen Caldwell, New Mexico Cooperative Fish and Wildlife Research Unit and Robert DuBey, New Mexico State University.** This project will evaluate the susceptibility of Rio Grande cutthroat trout (RGCT) to infection by *Myxobolus cerebralis* through paired laboratory challenges using commercially-reared rainbow trout of known sensitivity to whirling disease. RGCT presently occupies a fraction of its presumed historic range, and is considered "at risk" by the New Mexico Department of Game and Fish and "imperiled" by the U.S. Fish and Wildlife Service. If *M. cerebralis* were to spread into genetically isolated populations of RGCT, they would be at great risk of infection. Increased disease susceptibility of several cutthroat trout subspecies when compared to rainbow trout has been demonstrated using sentinel fish. This study will use a controlled laboratory approach using a suite of diagnostic metrics to provide a more quantitative estimate of susceptibility for RGCT. Diagnostic metrics will include mortality, clinical symptoms (behavioral and skeletal abnormalities), histology, and DNA diagnostics of *M. cerebralis* (nested PCR) in both RGCT and rainbow trout. Accurate assessment of RGCT susceptibility will allow fisheries management agencies to formulate risk management strategies to mitigate for the effect of infection.



Fish showing typical clinical signs of whirling disease.

***Evaluation of increased survival of young-of-the-year wild rainbow trout in the upper Madison River in the face of increased whirling-disease infection intensities in wild rainbow trout spawning areas.* Patrick T. Clancey, Montana Fish, Wildlife and Parks and Billie Kerans, Montana State University.** Whirling disease remains a serious problem in the Madison River of Montana. From the disease's onset in the early 1990s, the recruitment of young wild rainbow trout into the fish population of the upper Madison River has been seriously compromised. The goals of this project are to determine if: (1) wild rainbow trout in the Madison River are beginning to develop some resistance to severe infections by *M. cerebralis*; (2) resident wild rainbow trout have changed their primary spawning, hatching, and rearing sites from the sites utilized in 1998-99; (3) resident wild rainbow trout are spawning in an earlier or later time period than found in 1998-99, when the potential for high infection rates of hatching and emerging young rainbow is less likely to occur; and (4) there has been a change in the rate or level of infection of *Tubifex tubifex* populations in various side channels that were heavily utilized by spawning rainbow trout in the late 1990s.

Analysis of epidemiology data for whirling disease in the Rock Creek (Montana) drainage: 1998-2003. **Willard O. Granath, University of Montana.** During the summer of 1998, a study of whirling disease was initiated in the Rock Creek Watershed, Montana with the expectation that it would be a long-term research effort. These studies have continued uninterrupted to date and have brought together the expertise of numerous investigators. The following has been learned about *Myxobolus cerebralis* in Rock Creek: (1) both the prevalence and severity of *M. cerebralis* infections in sentinel rainbow trout increased dramatically throughout the drainage between 1998 and 2003; (2) an increase in disease severity was not accompanied by an increase in the number of *T. tubifex* recovered or an increase in the prevalence of *M. cerebralis* infected *T. tubifex*; (3) the parasite is still expanding its range within Rock Creek; (4) sentinel fish become infected at many sites where no infected *T. tubifex* are recovered and it is likely that fish at these sites are being infected by infective spores that originated miles upstream; and (5) decreasing streamflow is likely to play a major role in increasing disease severity.

Since 1998, a large set of epidemiological data for Rock Creek has been generated, including: (1) disease severity in trout, using sentinel cages placed throughout the Rock Creek drainage; (2) prevalence of *M. cerebralis* in *T. tubifex* from numerous locations throughout Rock Creek; (3) quantitative macroinvertebrate sampling throughout Rock Creek; (4) habitat evaluation of Rock Creek using EPA habitat assessment protocols; (5) water quality measurements (temperature, pH, dissolved oxygen, total dissolved solids, etc.) at sentinel cage and other locations; and (6) water flow measurements (since 2001) at sentinel cage and other sites. These data require significant analysis and interpretation which should lead to a better understanding of disease transmission in this drainage, and will aid fishery biologists in making management decisions. The major goal of this project is to analyze the data generated for publication in peer-reviewed journals.

Movements of resident and non-resident anglers in Montana: implications of transferring whirling disease among drainages. **Christopher S. Guy and Alexander V. Zale, Montana Cooperative Fishery Research Unit; and Travis B. Horton, Montana Fish, Wildlife and Parks.** Despite numerous studies on the biology of *Myxobolus cerebralis*, little is known about its transfer among drainages by anglers. It is highly likely that anglers can transfer *M. cerebralis* based on the data that myxospores are found in the sediment, they are highly resilient to environmental stress, fishing equipment often captures benthic sediment, and anglers are highly mobile. This study will identify the likelihood of detecting myxospores relative to sediment amount, quantify the amount of angler movement among basins, quantify the amount of sediment on angling equipment, determine if the sediment on angling equipment contains myxospores, and determine sediment load and presence of myxospores on various wader and boot types. Results will help develop management strategies to reduce the spread of whirling disease throughout the Intermountain West.

Forensic applications of otolith microchemistry for tracking sources of illegally stocked whirling disease positive trout. **Brett M. Johnson and Gregory Whitledge, Colorado State University; Patrick J. Martinez, Colorado Division of Wildlife; and Dana Winkelman, Colorado Cooperative Fish and Wildlife Research Unit.** Maintenance of self-sustaining wild and native trout fisheries is jeopardized by the spread of whirling disease, but the extent to which illegally-stocked whirling disease positive fishes have contributed to this spread has been difficult to assess. This project seeks to develop a reliable method for determining origins of illegally-stocked positive trout through microchemical analysis of otoliths. Its goals are to: (1) determine the geographic resolution possible based on chemical signatures of otoliths and water samples from state hatcheries; (2) assess the utility of these signatures for tracing hatchery origins of fish at large; (3) determine variation in microchemical fingerprints and isotopic signatures of otoliths obtained from select

private hatchery fish; and (4) assess the utility of these signatures for tracing hatchery origins of fish at large.

***Use of high resolution thermal imagery as a tool to locate* Tubifex tubifex *in Pelican Creek, a* Myxobolus cerebralis *positive stream in Yellowstone National Park*. Billie Kerans, Montana State University and Todd Koel, National Park Service.** *Myxobolus cerebralis* is the cause of a recent, significant decline of spawning, native Yellowstone cutthroat trout in Pelican Creek, a large tributary to Yellowstone Lake. The goal of this project is to examine the potential of high resolution thermal imagery and habitat characteristics to detect "hot spots" of *M. cerebralis* infection and high *T. tubifex* abundance. Water temperature plays a critical role in development of the parasite in its fish and worm hosts. Researchers will validate NASA thermal imaging as a tool for locating areas of high *M. cerebralis* severity by linking it with infection risk, which is assessed using infection in tubificids. Objectives are to: (1) document *M. cerebralis* infection risk in Pelican Creek using infection in *T. tubifex* and sentinel fish exposure (where possible); (2) assess the habitat characteristics (both physical and chemical) where tubificids are collected; and (3) correlate *M. cerebralis* infection risk to habitat characteristics and high resolution, thermal imagery. The outcome of this work may result in a non-invasive tool to target areas of high *M. cerebralis* infection in stream systems of the Intermountain West.

American white pelicans from the Molly Island colony, Yellowstone Lake.

Myxobolus cerebralis *in a pristine environment: the role of American white pelicans as a dispersal vector in the Greater Yellowstone Ecosystem.* Todd Koel, National Park Service and Billie Kerans, Montana State University. *Myxobolus cerebralis* is prevalent in native Yellowstone cutthroat trout. Infection severity is extremely high in Pelican Creek, the second largest cutthroat trout spawning tributary and a common foraging stream for American white pelicans (*Pelecanus erythrorhynchos*). Dissemination of *M. cerebralis* in the region is blamed primarily on movement of infected fishes by humans. However, no fishes have been (legally) transported to the waters of the Yellowstone Lake basin or in many places elsewhere in Wyoming where the parasite now exists. The goal of this study is to determine the potential of American white pelicans as a dispersal vector for *M. cerebralis*. In the Yellowstone Lake ecosystem and elsewhere, white pelicans are feeding, moving among waters, and defecating. Unknown is the potential viability of any defecated *M. cerebralis* myxospores. Specific project objectives are to: (1) examine white pelican feces for the presence of *M. cerebralis*; and (2) determine if any defecated myxospores are capable of infecting *Tubifex tubifex* resulting in viable *M. cerebralis* triactinospores. Results will provide some of the first information on the potential of a common avian piscivore to spread *M. cerebralis* among waters in Yellowstone National Park and throughout the western United States.

***The potential of vehicles and fomites to transfer the agent of whirling disease*. Paul W. Reno, Oregon State University.** This study will determine the likelihood of transferring the agent of whirling disease from site to site by a mechanism other than movement of fish. Two likely methods of transfer to be examined are passive transfer by birds and movement via contaminated wader boots. This project will determine if: (1) piscivorous/scavenger/herbivorous birds can transfer

the agent of whirling disease to either piscine or tubificid hosts over a short time interval, thereby emulating scenarios that might occur in a field situation; and (2) angler-associated fomites, specifically waders, can transfer the agent of whirling disease to either piscine or tubificid host over a short time interval, emulating inadvertent transfer from watershed to watershed during fishing.

The role of sediment size distribution and other microhabitat factors in the abundance and relative dominance of various* T. tubifex *lineages. **Dana Winkelman, Colorado Cooperative Fish and Wildlife Research Unit; Terry Waddle, Jim Terrell, and Robert Milhous, U.S. Geological Survey; and Kevin Thompson, Colorado Division of Wildlife.** Research and monitoring in Spring Creek and the William's Fork River indicate that these sites are dominated by strains of *T. tubifex* that differ in their susceptibility to infection by whirling disease. In this study, researchers will examine the relationship between habitat variables and the distribution and abundance of *T. tubifex* lineages in these systems. Potential differences in habitat requirements for the different strains will be evaluated by comparing strain abundance and dominance (as determined by PCR analysis and paired kicknet/core samples) with particle size distributions and organic content of core samples at each stream site. Researchers will conduct similar evaluations on the Poudre River in 2005 to assess habitat relationships in another system.

7TH INTERNATIONAL SYMPOSIUM ON FISH PHYSIOLOGY, TOXICOLOGY AND WATER QUALITY

This symposium, organized by the Montana Water Center, convened on the shores of the Baltic Sea in Tallinn, Estonia May 12-15, 2003. Sixty-five scientists and students from sixteen nations gathered to discuss work related to eutrophication and hypoxia, as they affect both freshwater and marine fishes. Symposium sponsors included the U.S. Environmental Protection Agency, the Estonian Academy of Sciences, the Estonian Agricultural University, the International Section of the American Fisheries Society and Montana State University.

In 2004, the Water Center brought out the proceedings of the meeting. The 23 papers address the global spread of hypoxia and anoxia in large water bodies, and the land use practices that drive the phenomenon. Toxicology papers focus on effects of hypoxia and metals on fish survival, and effects of ammonia toxicity on fish organ systems and biochemistry. Papers that address fish physiology and behavior range from oceanic distribution of cod as a function of temperature, to behavior of reef fishes during diurnal cycles of oxygen depletion, to blood hemoglobin regulation in hypoxic fish. Papers dealing with biogeochemistry cover the water quality conditions of the Gulf of Finland and of lakes in Estonia, the modeling of metal binding on humic substances, and a large-scale ecological modeling approach for predicting estuarine water quality conditions. Find the 358-page proceedings at: http://water.montana.edu/symposium/proceedings/.

Participants of the 7th International Symposium.

WILD FISH HABITAT INITIATIVE

Degradation of fish habitat is one of the principal reasons for the listing of wild fish under the Endangered Species Act. Along with degraded habitat comes an influx of exotic competitors and diseases. Land values, too, are diminished by habitat degradation and the subsequent loss of wild fish populations. In recent years, many techniques of fish habitat enhancement have been implemented, but their long-term efficacy is not well understood because few projects include long-term monitoring of fish populations, and results of those projects are not widely publicized. The purpose of the Wild Fish Habitat Initiative is to enhance the success of restoration projects by conducting targeted research related to habitat restoration techniques, and by providing technical information to landowners and project managers. The Initiative is a scientific adjunct to the Partners for Fish and Wildlife Program of the U.S. Fish and Wildlife Service. The Partners Program, in turn, is a national effort to restore fish and wildlife habitat through collaborations with landowners.

Technology Transfer (2002-present)

In recent years, many fish habitat enhancement and restoration techniques have been implemented, but project results generally have not been shared or exist only in "gray literature" where they are difficult to access. To address this problem, we are collating information on methods and results of well-documented fish habitat restoration projects that have been conducted in the Intermountain West (Colorado, Idaho, Montana, Nevada, Utah, Wyoming, and inland areas of California, Oregon, and Washington). Information is organized in a searchable bibliography and case history database, accessible at: http://wildfish.montana.edu/.

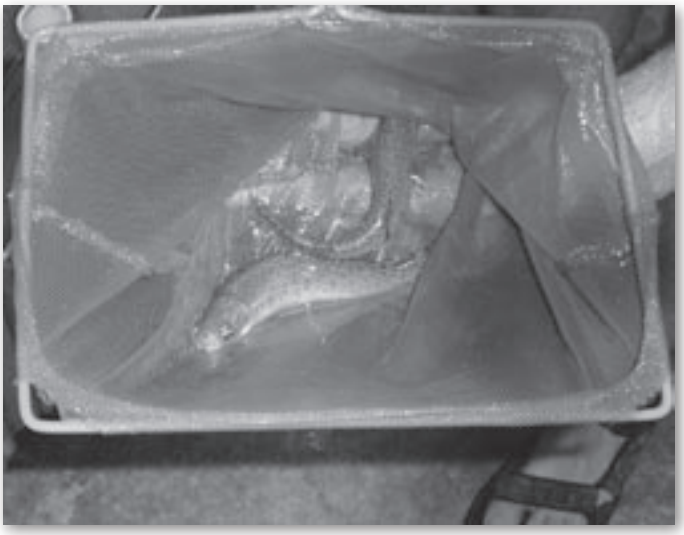
Research Projects

Evaluation of entrainment losses of westslope cutthroat trout at private irrigation diversions on Skalkaho Creek, Montana (2002-2005). **Alexander V. Zale, Montana Cooperative Fishery Research Unit; Thomas McMahon and Steve B. Gale, Montana State University; and Christopher G. Clancy, Montana Fish, Wildlife and Parks.** This project will provide an in-depth evaluation of fish screens. Objectives are to: (1) quantify downstream migrating juvenile trout entrained or bypassed at irrigation diversions on Skalkaho Creek, Montana, before and after fish-screen and siphon installation; (2) evaluate passage efficiency of fish screen structures; and (3) estimate the recruitment contribution of Skalkaho Creek to the Bitterroot River.

Seven lowhead irrigation dams on lower Skalkaho Creek, a tributary to the Bitterroot River in Western Montana, divert significant numbers of downstream migrant westslope cutthroat trout (*Oncorhynchus clarki lewisi*) into eight irrigation canals. Post-spawn adults migrating back to the Bitterroot River and juveniles emigrating downstream from nursery areas in upper Skalkaho Creek become trapped and die in the irrigation canal system, resulting in a net loss to the population. Landowners and irrigators have agreed to install fish screens and siphons at some of the diversions to preclude such losses. The screens were installed in 2003 and installation of the siphons is projected for late 2004. The first phase of the study provided a baseline estimation of fish losses in 2003, prior to installation of the screens. Researchers observed significant

entrainment at the unscreened diversions. The second phase of this study provides initial post-screen-installation data for comparison. Under the third phase, researchers will continue to evaluate the efficacy of the screens and siphons, and estimate the increased recruitment contribution of trout to the Bitterroot River that these structures facilitate. Results should reinforce opportunities for landowners and agencies to invest in fish screens and siphons as part of their fish habitat management efforts.

Thermal requirements of westslope cutthroat trout (2002-2004). **Thomas McMahon and Beth Bear, Montana State University; Alexander V. Zale, Montana Cooperative Fishery Research Unity; and Bill Krise, U.S. Fish and Wildlife Service.** Historically, westslope cutthroat trout ranged widely in the northwestern United States. Now, like many native trout species, westslope cutthroats persist in only a small portion of their native range, and are listed as a "species of special concern" in Montana. Their decline is attributed to habitat degradation and displacement by non-native rainbow, brook, and brown trout. Water temperature influences the abundance and distribution of trout, yet the thermal requirements of westslope cutthroat trout are largely unknown, meaning they cannot be managed optimally.



Westslope cutthroat trout

This study will characterize the thermal biology of westslope cutthroat trout, specifically with respect to the lethal and optimal temperatures for this subspecies, and compare its thermal biology with that of rainbow trout, a nonnative competitor. The research design allows simultaneous assessment of fish growth and survival under many different temperatures over long time periods.

Preliminary results indicate the ultimate upper incipient lethal temperature (UUILT) for westslope cutthroat trout to be near 21°C and the optimum growth temperature to be near 13°C. Results also indicate the UUILT for rainbow trout to be near 24°C. Other results will allow comparisons between these two species with respect to the role water temperature may play in their survival and growth. The fourth and final experiment will refine the upper lethal limit and growth optimum temperature of westslope cutthroat trout and rainbow trout.

Bacterial coldwater disease in westslope cutthroat trout: hatchery epidemiology and control (2002-2004). **Eileen K.N. Ryce and Alexander Zale, Montana Cooperative Fishery Research Unit.** Bacterial coldwater disease, caused by the gram-negative bacterium *Flavobacterium psychrophilum*, is responsible for significant losses of hatchery-reared salmonids worldwide. The research team used Washoe Park State Fish Hatchery in Anaconda, Montana, as a case study to develop practical hatchery-management strategies to control the pathogen and the disease. Washoe Park typically loses 30 to 45 percent of its westslope cutthroat trout (*Oncorhynchus clarki lewisi*) production to the disease annually. Study objectives were to determine where the pathogen was located in the hatchery system, how it was transmitted, and what factors caused disease outbreaks. Researchers found the bacterium in the warm-spring water source, in the degassing water tower, and in production and broodstock fish. It was transmitted both horizontally and vertically, with both male and female parents passing the pathogen on to their offspring. Transmission from females was vertical only, but both horizontal and vertical transmission from males occurred. Iodine surface-disinfection post-fertilization eliminated the pathogen from egg surfaces, thereby limiting horizontal

transmission. Chronic and mild acute stress did not result in disease outbreaks, but a combination of acute stress events associated with moving juvenile production fish from indoor to outdoor raceways did. These fish harbored the pathogen, primarily in cranial tissues, prior to the outbreak. Measures to reduce horizontal transmission included cleaning and sterilization of hatchery structures and iodine surface-disinfection of eggs post-fertilization. Eradication of the pathogen from the hatchery is unlikely, but efforts to reduce the frequency and intensity of stress events should reduce the frequency of disease outbreaks.

Evaluation of the efficiency and efficacy of non-native fish eradication and exclusion techniques for native fish restoration (formally called Fan Creek Westslope Cutthroat Trout Restoration Project) (2003-2005). **Alexander Zale, Montana Cooperative Fishery Research Unit; and Peter Brown and John Olson, Montana State University.** Predation and competition for resources can drive native populations to extinction while hybridization reduces the overall genetic integrity of native populations. Fishery restoration projects employ fish toxicants and fish barriers to conserve threatened and endangered species and rid water bodies of non-native species. However, little standardization of these techniques exists and evaluations of success or failure are rarely conducted. Cutthroat trout in Yellowstone National Park's Fan Creek were thought to be genetically pure until recent studies showed that they contain rainbow trout genetic material. The planned restoration of Fan Creek was therefore canceled. This research project is therefore moving from Fan Creek to restoration projects at Costilla Creek, New Mexico; Labarge Creek, Wyoming; and Cherry Creek, Montana. The goal of this project is to increase the success rate of native fish restoration projects. Researchers will investigate eradication techniques and interview project leaders to identify state-of-the-art methods of fish removal and barrier design. They'll then evaluate selected restoration projects more than five years after fish removal and exclusion. Subsequent field and laboratory research will focus on increasing the efficiency of eradication and exclusion protocols through direct experimentation.

Fish barrier

Thermal requirements of Yellowstone Cutthroat Trout. **Thomas McMahon, Montana State University; Alexander V. Zale, Montana Cooperative Fishery Research Unit; and Cal Fraser, Montana Water Center.** Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) are in decline throughout their native range in the Northern Rockies, are listed as a Species of Special Concern in Montana, and have been petitioned for listing under the Endangered Species Act. Habitat degradation and competition by non-native trout are the primary causes of their decline. Water temperature is widely regarded as playing a key role in native salmonid persistence, yet specific thermal requirements of cutthroat trout subspecies are largely unknown. Water temperature also plays an important role in tipping the balance in favor of non-native over native trout, yet how temperature influences competitive interactions of Yellowstone cutthroat with their non-native competitors has not been investigated. This lack of information precludes effective reintroduction and restoration programs, development of land management policies, and hatchery propagation protocols.

Arctic grayling, bull trout, westslope cutthroat trout, and Yellowstone cutthroat trout are the primary native trout species in Montana, and all are listed as Species of Special Concern. The Yellowstone cutthroat trout

is the last remaining member of this group for which temperature data are unavailable. Acquiring thermal information on the Yellowstone cutthroat trout studies will promote effective habitat protection, restoration, and species reintroduction programs. Recent controversy over the role of bull trout temperature tolerances in development of land management policy clearly illustrates that having well-defined temperature criteria for now-rare fishes is important for effective protection and management. The information will be especially helpful in implementing conservation plans for this native cutthroat trout in Montana, Idaho, and Wyoming.

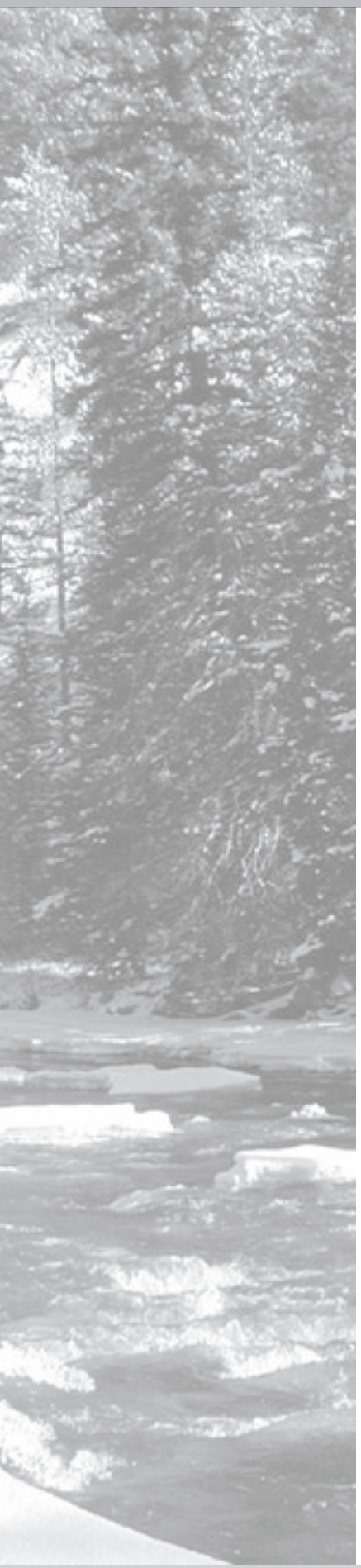
Yellowstone cutthroat trout

Evaluation of habitat restoration for the conservation of cutthroat trout. **Alexander Zale, Montana Cooperative Fishery Research Unit; and Brad Shepard and Mark Taper, Montana State University.** The distribution and abundance of native westslope (*Oncorhynchus clarki lewisi*) and Yellowstone cutthroat trout (*O. c. bouvieri*) have declined from historical levels and both are considered at risk for listing under the Endangered Species Act. Efforts are underway to conserve these subspecies throughout the Northern Rocky Mountain region. One strategy is habitat restoration, but few studies have assessed the response of cutthroat trout populations to restoration. In fact, few studies have described ideal habitats for the conservation of these subspecies. Another major threat to the conservation of these subspecies is competition and predation by non-native trout species, particularly brook trout (*Salvelinus fontinalis*), that occur in sympatry with both subspecies over much of their range. Interactions between brook and cutthroat trout are likely regulated by habitat condition, but little is known about these relationships. This study will evaluate habitat restoration and enhancement projects to assess whether these projects resulted in increased densities or distributions of cutthroat trout. In the future, the research team will describe what constitutes quality habitat for westslope and Yellowstone cutthroat trout and determine how habitat condition and the presence of brook trout interact to affect densities of cutthroat trout.

The Wild Trout Research Lab has been in operation since the summer of 1997, primarily to serve regional investigators conducting whirling disease research. During the past year, Yellowstone National Park researchers utilized the lab as a holding facility for field-exposed fish from in and around Yellowstone Lake. To assess expansion of the disease in Montana, Montana Fish, Wildlife and Parks conducted several exposure studies using the lab as a holding facility, and U.S. Fish and Wildlife Service researchers tapped the facility to evaluate the feasibility using the PCR diagnostic technique to test for disease severity. As part of an ongoing service, the Wild Trout Research Lab maintained stocks of infected fish and distributed whirling disease spores to researchers across Montana.

Lab technician at work.

Tubifex worm culture system.



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COVER PHOTO:

The original photo (left) was taken by Bill Uthman, Hydrogeologist, Montana Department of Natural Resources and Conservation. It was taken in the Blacktail Deer Creek Valley with the Blacktail Range in background and East Bench Irrigation District Canal in foreground (Upper Beaverhead Basin). The original color photo was modified using a watercolor filter to achieve the look shown on the cover.

Montana State University Campus and the Gallatin Valley.
Photo courtesy of Rick Jackson.